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SOLAR TRACKING HEAD

(Solnechnaya sledyashchaya golovka)

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The described tracking head is designed for a joint operation with the diffraction spectrometer for the measurement of solar radiation in the far ultraviolet. Its task consists in directing the mirror-reflected beam of solar rays into the spectrometer's slit for different positions of the spectrometer. The required precision of luminous flux direction into the slit is of ±10 angular minutes.

The constructive-kinematic layout of the tracking head is brought out in Fig.1. The photographic view of the tracking head's block is shown in Fig.2. The exterior frame 2 is fastened to the support 1. The axis of the frame is connected with the motor by means of a reductor. A mirror 4 is fastened together with a pivotal axis 5, to the exterior frame. The system is set in motion by the motor 6 through the reductor. In the figure it is concealed inside a casing. The axle 5 and that of the mirror – 4 are parallel. They are linked by a crank 7 assuring a 1 : 2 transmission with minor angular errors. There is in the frame an aperture through which the mirror-reflected luminous flux penetrates into the spectrometer. A solar pickup 9 is installed on the exterior frame, while pickups 8 and 10 are fastened to the axle 5. The sensitive parts of these pickups are constituted by photo-varistors.

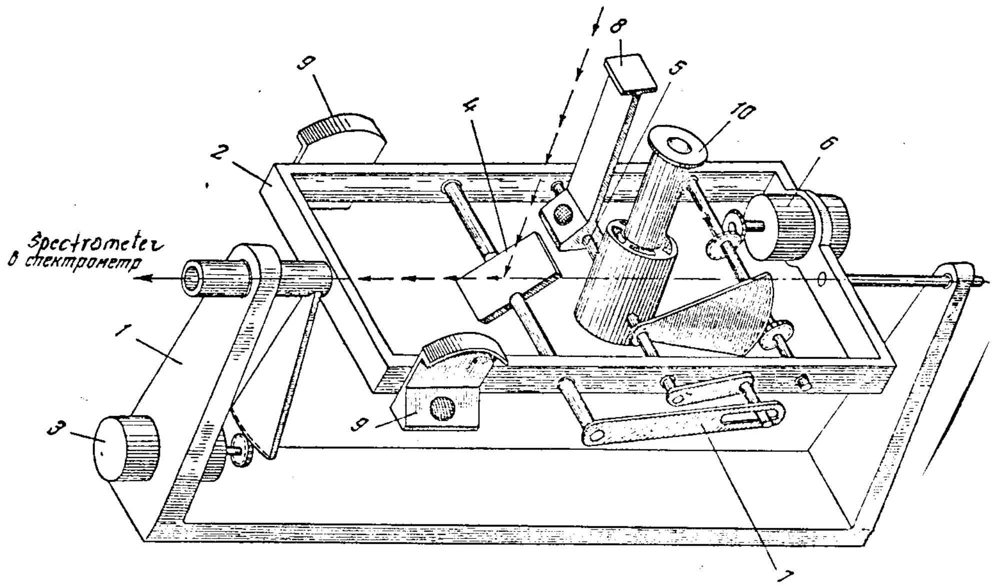

Fig.1 - Constructive-kinematic layout of the layout of the tracking head.

1 — support ; 2 — exterior frame ; 3 — motor assuring rotation relative to the longitudinal axis ; 4 — mirror ; 5 — inner axle ; 6 — motor assuring rotation relative to the transverse axis ; 7 — crank ; 8 — pickups of rough orientation in the longitudinal direction ; 9 — ibid. for the transverse direction ; 10 — pickup for a precise orientation.

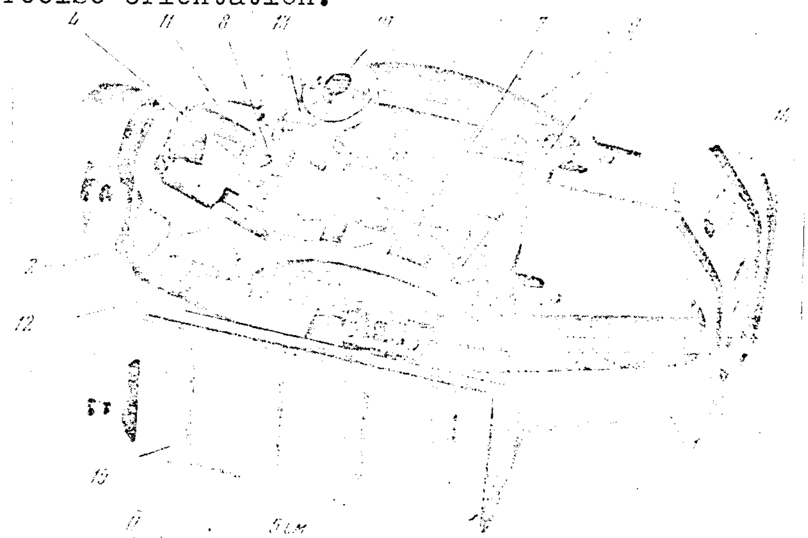

Fig. 2. Exterior view of the tracking head block.
1 — 10 - see Fig.1. 11 — Balancing loads of the mirror ; 12 — b.l. of the exterior frame ; 13 — Bal.load of parts of the inner axle ; 14 and 15 — screens of the rough orientation pickups.

The block-diagram of Fig. 3 refers to rough orientation pickups. A visor 2 is fastened to the stand 3 over a pair of photo-varistors 1, symmetrically disposed relative to the axis OO'. When the pickup is illuminated by a beam of light parrallel to the symmetry plane of the photo-varistor pair, the visor shades the operating surfaces of that pair equally. The visor's dimensions are so selected, that its shade cover half of ecah photo-varistors' operating surface. The photo-varistors are disposed at an angle of 45° with the symmetry plane so as to increase the pick-up's visual field. In the given case it exceeds 240°.

The pickup 8 (Fig. 1) acts relative ot the head's transverse axis. It constitutes a single node represented in Fig. 3. The pickup 9, operating relative to the longitudinal axis of the head, is divided constructio-wise (along the symmetry plane) into two halves spread along the framework of the exterior frame 2. In the latter case visors are made in a form of an arc, so as to ensure the pickup's operation within a great angular range relative to the transverse axis.

Pickups 8 and 9 cannot simultaneously assure a large visual field and a high tracking precision, for if the visual field is large, specks of reflected light from parts of the head and of surrounding objects may hit the sensitive parts of the instrument. Thus the problem of these pickups amounts to "search" for the Sun and to a rough orientation to its center. Pickup 10 serves for a precise orientation. In order to assure a precision of not less than ±10 angular minutes for the luminous flux' direction toward the slit, the pickup must guarantee a precision in aiming at the Sun substantially exceeding the indicated allowance. This is made necessary on account of the possibility of appearance of errors created by construction and setting up elements that lead to errors in the orientation of the reflected flux.

The obtention of high tracking precision is linked as a rule either with the utilization of long-focus optical systems, in which the image of the Sun is constructed on the surface of several sensitive components [1], or of systems in whose focal plane an obturator rotates (with a single sensitive element) [2]. In view of the small size of the head's block, the application of the indicated systems was excluded. Basically, the same principle was applied to the construction of the precise pickup with some variants than that for the rough orientation pickup.

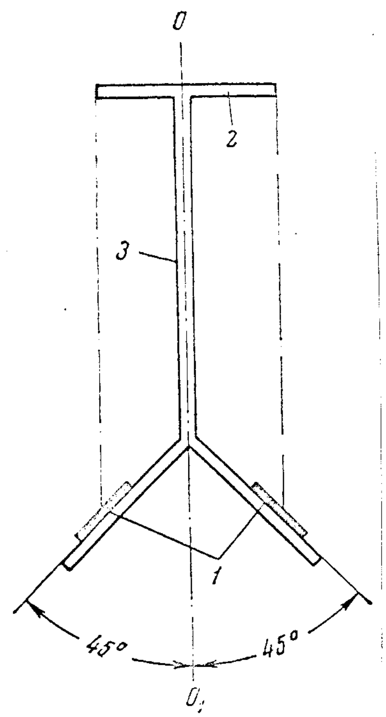

Fig. 3.- Block-diagram of the rough-orientation pickup.

All elements of the precise pick up were merged into a single node, above which a general circular visor was placed. This pickup emits deflection signals by both axes. In order to shield it from the effect of alien light reflections, the pickup was placed in a protective glass, limiting the visual field of the sensitive elements. Experiments have shown that the applied construction of the pickup had assured the required aiming precision. For a change-over in the tracking regimes from the rough to the precise, a special commutator with a photo-optical pickup was applied. The change-over takes place at Sun's appearance in the visual field of the pickup designed for a precise orientation. Construction-wise the photo-optical pickup was built-in around the pickup's 10 support on which the circular visor is fixed. It may be seen in Fig. 2, how the objective is fixed at the front end of the pickup 10.

The power-driven motors 3 and 6 with the reductors are respectively placed on the support and on the exterior frame. Both motors are oriented along the tracking head's longitudinal axis. This is meant for creating lighter conditions for the motors from the standpoint of overload effect. All the mobile elements were carefully balanced by special loads. Fig. 2 shows the balancing loads of the mirror — 11, of the exterior frame — 12 and of the parts of the interior axle — 13. The same figure shows the screens — 14 and 15, shielding the rough-orientation pickups from strong aliens brightenings not connected with the Sun.

For its coupling with the spectrometer the tracking head's block is provided with a basic surface relative to which the orientation of the mirror-reflected beam precisely takes place. The given tracking head's construction layout allows the tracking of the Sun within the following angle limits : 120° in the plane normal to the longitudinal axis, and 110° in the plabe perpendicular to the transverse axis.

The priniciple of the tracking head's electrical circuit is presented in Fig. 4.

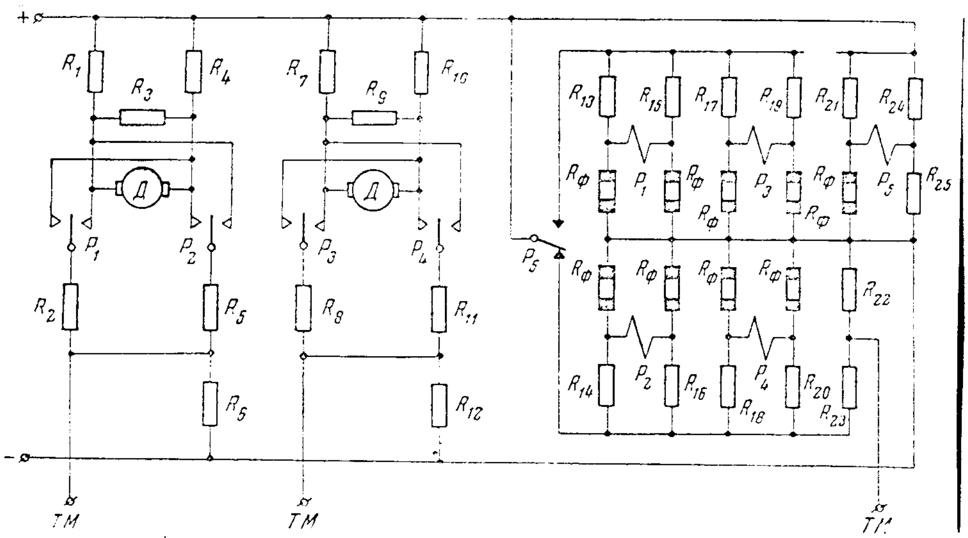

Fig. 4. Simplified circuit diagram of the tracking head.

R_1 — R_{25} — resistances ; P_1 — P_5 — relays ; Д — motors ; $R_Ф$ — photo-varistors ; T M — Telemetry contacts.

It may be seen from the circuit diagram that the three-position polarized relays constitute the amplifying elements. The coils of these relays are inserted into the diagonals of four bridges, whose two shoulders form the photo-varistors $R_Ф$, and two other —

permanent carbon resistors. There are five bridge circuits in Fig. 4: two circuits controlling the tracking in a plane normal to the longitudinal axis, — precise in the relay P_1 and rough in the relay P_2; two circuits for tracking in a plane normal to the transverse axis with the P_3 and P_4 relays in the diagonals. Besides, there is a change-over bridge circuit from the rough to the precise tracking, consisting of one photovaristor pickup's switch, of three permanent resistors and of a two-position polarized relay P_5. The switch assures the change-over of the feed from the rough to the precise tracking bridge circuits.

For the control of the head's operation, signals from the switch and from the motor control circuit are fed to telemetry channels TM, respectively through the divider R_{22}, R_{23} and from the resistors R_6 and R_{12}. D.c. assures the circuit's feed.

The movement of the tracking head operates in two velocity regimes : 1) "searching" of the Sun and rough guiding, regime which is conditioned by the assigned minimum search time ; 2) precise tracking regime selected from the conditions of optimum tracking dynamics.

The reductors' transmission ratios, the values of the resistors R_1, R_3, R_4, R_7, R_9 and R_{10} influencing the damping magnitude, and also the values of resistors R_2, R_5 and R_8, R_{11} influencing the velocity magnitude have been determined by dynamic computation. All the parts of the electric circuit, with the exception of motors and photo-varistors, were placed in a special commutation block (switch) installed inside the spaceship-satellite. The block itself consists of a frame on which fastened are the polarized relay, and of two braced panels, for the fastening of the circuit's components.

The operation of the whole tracking system took place as follows :

In the absence of luminous flux the resistors of sensitive elements are practically identical. At the same time the bridges are equilibrated, the contacts of the relays P_1, P_2, P_3 and P_4 are in a neutral position, the motors — disconnected. The feed of rough-orientation bridge circuits ias assured by switching on the contact relay P_5. Inasmuch as the magnitude of the dark resistor R_Φ is very great, the consumption of power by these circuits is small. At illumination of any of the rough orientation system's photovaristors, the equilibrium of the corresponding bridge circuit is disrupted and the current begins to flow in the diagonals. At reaching the operation threshold, the relay provokes the closing of its contact and the motor connection. The motor then will turn the pickup toward the direction where the difference in illumination of the photovaristor pairs tends to decrease, i.e. in the direction toward the light source. The motion will continue until the illuminations of the photovaristors become equalized. Meanwhile, the bridge will be put in equilibrium, and the relay will pass into the neutral position disconnecting the motor.

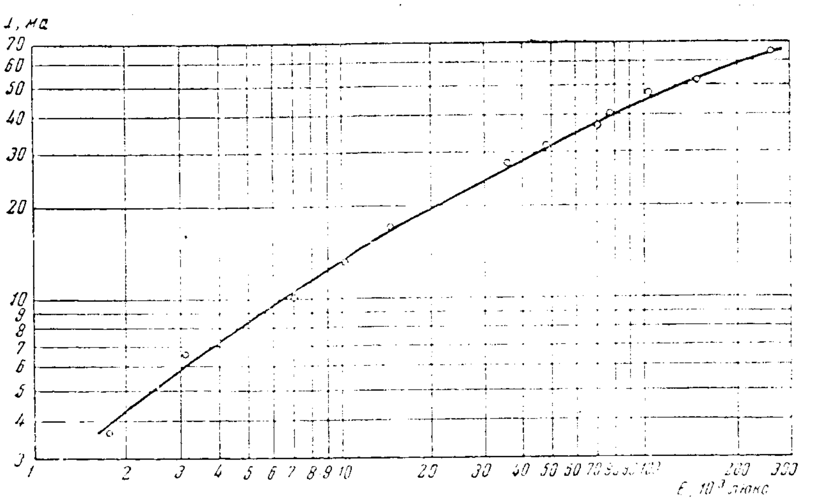

Fig. 5. - Light characteristic of the photovaristor C-K_1. The characteristic has been taken at 30 v with the help of a tube КСШ — 1000.

The feed change-over to the precise tracking orientation takes place at time of Sun's hitting the visual field of the photo-optical pickup's regime switch. At the same time the rough orientation circuit is automatically switched off. The operation of the precise tracking circuit is analogus to that of the rough orientation.

Inasmuch as the mirror 4 (see Fig. 1) is fastened with the frame 2, at time of turning relative to the longitudinal axis of the head the normal of the mirror is brought into the plane common to the direction toward the Sun and to the longitudinal axis of the head. The mirror will turn relative to the transverse axis at an angle twice smaller than the axis 5 (because of the presence of a rocker transmission) and will stop in a position for which the beam of reflected solar rays is directed along the head's longitudinal head into the spectrometer's slit.

Let us bring forth certain brief characteristics of the system and its separate parts.

Industrial cadmium sulfite type- ФС-КО (ФС-К$_1$) photovaristors are used as orientation and tracking pickups' sensitive elements. For the given type the spectral characteristic maximum is in the region $\lambda \approx 6000$ Å, and the dark resistor $R_{\Phi T} \geqslant 10^7$ ohm [3].

The luminous characteristic $I = f(E)$ for high values of illumination of these photovaristors is plotted in Fig. 5. The experimental data were taken by a xenon lamp of superhigh pressure ДКСШ – 1000, whose radiation has a spectral composition, close to that of the Sun in the visible region [4].

The characteristic of the rough orientation pickup is given in Fig. 6. Plotted is the dependence of the current in the bridge's diagonal on the rotation angle of the pickup. The beginning of the count is the symmetry plane OO' (Fig. 3). The experimental data were taken in field conditions, and in order to protect the apparatus from sky's scattered light, screens were used. All pickup's sensitive elements were shielded by glass 2 mm. thick. (In Fig. 2 glass has been taken away).

Small d.c. motors with independent excitation were used for driving power. They were provided with commutator bars and brushes made of ann alloy containing a great percentage of gold. The mirror was made of fused quartz, with its reflecting surface being covered with a thorium dioxide layer. All materials and coverings were so selected as to achieve optimum thermal regime conditions. The block ktself was mounted by multiple-core cable with a fluoro-stratified isolation. This made the connecting gad-dgets particularly flexible and strong.

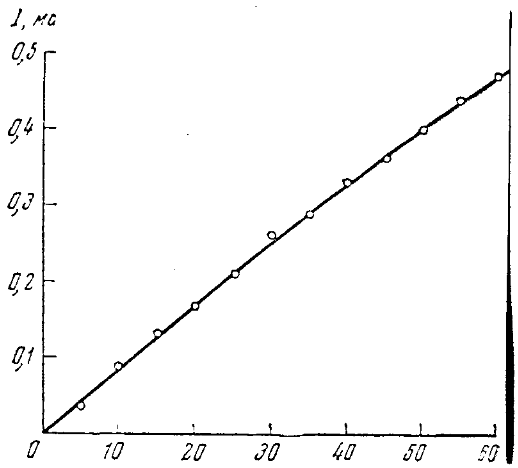

Fig. 6. Characteristics of the rough-orientation pickup. Ordinates — current in the bridge's diagonal. Abscissa — — deflection α from the symmetric position (in angular min.)

Polarized relays of the РПС-5 and РПС-7 type of high sensitivity were used, though at a rather great weight. However, the application of any other lighter relays with greater power consumption, would have only led to considerable weighting of feed sources, which would have overlapped the difference in relay weigths.

The weight of the tracking head is 1.65 kg, that of the commutation block — 2.65 kg. Mean power consumption — 0.7 w.

The element tuning was carried out in field conditions on a parallactic stand of the АПШ -31 type with the help of a special installation, as shown in Fig. 7. The tracking head was fastened at its basic surface to the plateau 5. The plane of the control mirror 2 was established parallel to the basic surface A.

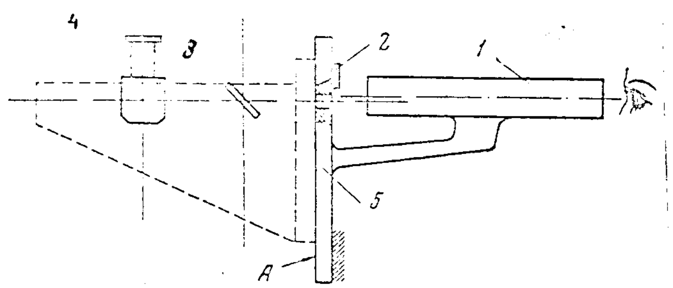

Fig. 7. Installation for tuning and checking the tracking head.
I — auto-collimator ; 2 — control mirror ; 3 — tracking head's mirror ; 4 — precise orientation pickup ; 5 — plateau.

The auto-collimator axis along the mirror 2 was established perpendicularly to the surface A. After t e indicated preparations tuning of the tracking head elements was effected according to the position of the Sun's picture on the auto-collimator's coordinate grid. The same installation served to verify the precision of Sun tracking, and that of the orientation of the reflected light beam during the tracking head's rotation relative an arbitrary axis.

The tracking head experiments have shown, that the precision in the direction and retaining of the beam in spectrometer's slit corresponds well to the requirement for a satisfactory tracking dynamics.

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